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A CHALLENGE TO CIVILIZATION

By Dr. NIELS BOHR

COPENHAGEN

THE advance of physical science which has made it possible to release vast amounts of energy through atomic disintegration has initiated a veritable revolution of human resources, presenting civilization with a most serious challenge. Man's increasing mastery of the forces of nature, which has provided ever richer possibilities for the growth of culture, may indeed threaten to upset the balance vital for the thriving of organized communities, unless human society can adjust itself to the exigencies of the situation. The great technical developments of the last century already deeply affected the social structure of every country but, evidently, we have now reached a stage which calls for a new approach to the whole problem of international relationship.

The formidable means of destruction which have come within reach of man will obviously constitute a mortal menace to civilization unless, in due time, universal agreement can be obtained about appropriate measures to prevent any unwarranted use of the new energy sources. An agreement to this purpose will surely demand the abolition of barriers hitherto considered necessary to protect national interests but now standing in the way of common safety against unprecedented dangers. In fact, only international control of every undertaking which might constitute a danger to world security will in future permit any nation to strive for prosperity and cultural development without constant fear of disaster.

Whatever renunciations as regards customary prerogatives such regulation will involve, it should be clear to all that, in contrast to other issues where

history and traditions may have fostered divergent viewpoints, we are here dealing with a matter of the deepest interest to all nations. Moreover, the free and open access to information about all scientific and technical progress, which will be a basic condition for the efficiency of the control, will in itself go far towards promoting mutual knowledge and understanding of the cultural aspects of life in the various countries, without which respect and good-will between nations can hardly endure.

In all the circumstances it would appear that the possibility of producing devastating weapons, against which no defence may be feasible, should be regarded not merely as a new danger added to a perilous world, but rather as a forceful reminder of how closely the fate of all mankind is coupled together. Indeed, the crisis with which civilization is at present confronted should afford a unique opportunity to remove obstacles to peaceful collaboration between nations and to create such mutual confidence as will enable them jointly to benefit from the great promises, as regards human welfare, held out by the progress of science.

The attainment of this goal, which places upon our generation the gravest responsibility towards posterity, will of course depend on the attitude of all people. Valuable services, however, may be rendered by scientists all over the world in bringing about a genuine appreciation of what is at stake and in pointing out how the great development of our resources may contribute to progress for humanity. In a matter of such universal scope, help may also be found in the intimate connections between scientists, created by international cooperation which proved so fertile just in a domain of research that was to have such overwhelming consequences.

For meeting the challenge to civilization in the proper spirit it should be a most fortunate omen that we have to do with implications of pure scientific studies pursued with no other aim than to widen the borders of our knowledge and to deepen our understanding of that nature of which we ourselves are a part. Let us hope that science which, through the ages, has stood as a symbol of the progress to be obtained by common human striving, by its latest emphasis on the necessity of concord, may contribute decisively to a harmonious relationship between all nations.

THE ROLE OF BACTERIA IN THE FORMATION AND TRANSFORMATION OF PETROLEUM HYDROCARBONS[1,2]

By Dr. CLAUDE E. ZOBELL

ASSOCIATE PROFESSOR OF MICROBIOLOGY AND DIRECTOR OF API RESEARCH PROJECT 43A, SCRIPPS INSTITUTION OF OCEANOGRAPHY OF THE UNIVERSITY OF CALIFORNIA, LA JOLLA

PETROLEUM is a complex mixture of gaseous, liquid and solid hydrocarbons. Besides the uncounted hundreds of hydrocarbons composing petroleum, there are numerous compounds of hydrogen and carbon which contain oxygen, nitrogen, phosphorus or sulfur. Petroleums from different oil fields differ widely in chemical composition and in physical properties. Some crude oils such as those from the Bradford, Pennsylvania, sands, for example, are clear amber-colored, free-flowing fluids, while others, exemplified by La Brea, California, crudes, are coal black, viscous tars. The density of petroleums ranges from a specific gravity of 0.65 (certain crudes from the Baku field in Russia) to somewhat more than 1.00 for oil from Athabaska (Alberta, Canada) tar sands. The range in the chemical composition of petroleums is as follows:

Carbon	82.2 to 87.1 per cent.
Hydrogen	11.7 to 14.7 " "
Sulfur	0.1 to 5.5 " "
Nitrogen	0.1 to 1.5 " "
Oxygen	0.1 to 4.5 " "
Minerals	0.1 to 1.2 " "

The hydrocarbons in various petroleums may consist predominantly of either (1) aliphatic compounds of the paraffin series, (2) aromatic compounds of the benzene series or (3) naphthenic compounds of the polymethylene or cyclo-paraffin series. Likewise, found in various crude oils are small quantities of fatty acids, phenols, naphthenic acids, resinous compounds, asphaltenes, mercaptans, thiophenes, sulfones, sulfoxides, sulfonic acids, organic sulfides, pyridines, quinolenes and other compounds. So complex are petroleums and so labile are some of their constituents that no crude oil has ever been completely analyzed.

In view of the ever-increasing importance of petroleum and its myriads of products to our mechanized and martialized civilization, it seems anomalous that our knowledge of what petroleum is and how it is formed is still so woefully wanting. Petroleum geologists have been so successful in finding subterranean

[1] Annual William Conger Morgan Memorial Lecture delivered before Alpha Kappa Chapter of Phi Lambda Upsilon and the department of chemistry, University of California at Los Angeles, April 25, 1945.

[2] Contribution from the Scripps Institution of Oceanography, New Series No. 265. These investigations were supported in part by a grant from the American Petroleum Institute, Research Project 43A.

deposits and the industry has been so efficient in providing almost any required amount of amazingly low-cost petroleum products that no one has been too much concerned about what petroleum is or how it was formed. The time has arrived, though, when more knowledge of petroleum and better discovery methods are urgently needed to maintain the supply of low-cost oil. Detailed information on the origin of oil may provide clues to the location of undiscovered petroleum deposits, and such information may affect the economy of exploiting them.

There are almost as many theories regarding the origin of oil as there are students of the subject. Some few still recite the conditions whereby petroleum may have had an inorganic or cosmic origin, but most petroleum geologists hold that "rock" oil had an organic origin. Supporting the organic theory are the nitrogen content of oil, its optical activity, the presence of pigments of the porphyrin type, and the association of oil with marine sediments containing plant or animal fossils. There are widely divergent views regarding the mode of transformation of organic matter into crude oil, but it is generally agreed that (1) the temperature of formation was probably less than 150° C. and it may have been no higher than 30° to 80° C., (2) the pressure of formation was relatively low, (3) the oil was formed not far from the places where it is now found, and (4) it was formed primarily, if not exclusively, in marine environments. Either physical, chemical or biological agencies may have contributed to the formation of oil.

It is not the purpose of this paper to elaborate the theories of petroleum genesis, but rather to discuss the possible part played by bacteria in the formation and transformation of petroleum hydrocarbons. Assuming that the organic remains of plants and animals constitute the mother substance of petroleum, there are several ways in which the biochemical activities of bacteria and allied microorganisms could be instrumental in the conversion.

Field and laboratory observations during the last decade have established that a biochemically versatile bacterial flora is associated with marine sediments, both recent and ancient. These bacteria or their enzymes (organic catalysts) could be functional in geological environments simulating those in which oil is found and in environments where oil is believed to be formed. Large populations of living bacteria are found in bottom deposits from the floor of the ocean and in reservoir fluids from oil wells. Conclusive proof is still lacking that bacteria are physiologically active in subterranean deposits of brine or oil, but bacteria are unquestionably functional in recent marine sediments to the greatest depths sampled, around 25 feet. Thousands of viable bacteria per gram were recovered from bottom deposits collected at depths exceeding 20 feet below the sea floor. Extrapolating the curve for the vertical distribution of bacteria in recent marine sediments suggests that the lower limits of the biosphere in sedimentary materials would be limited primarily by increasing temperatures at greater depths.

The greatest depth from which samples of sedimentary material have been collected aseptically for bacteriological analysis is 1,560 feet. Cores of limestone impregnated with anhydrite, sulfur and traces of organic matter taken from this depth were found to contain living bacteria capable of propagation in such material. Numerous bacteria are often found in oil coming from depths of several thousand feet, but it is not known whether these are indigenous species or if they are adventitious species introduced after the well was drilled. Nevertheless, the recovery of numerous bacteria years after the well was drilled indicates that they are reproducing in the formation.

From petroliferous sediments have been recovered bacteria, some of which can grow at temperatures as low as 0° C. and others which are physiologically active at temperatures as high as 85° C. The bacteria are not injured by hydrostatic pressures up to 150,000 pounds per square inch, a pressure which is approximately ten times that occurring five miles below the surface of the earth. Some of the bacteria thrive in low salinity water while others grow well in salt-saturated brines. From these observations it is concluded that neither salinity, hydrostatic pressure nor temperatures up to at least 85° C. can be expected to prevent bacterial activity in petroliferous environments.

Most of the bacteria are facultative anaerobes. They attack nearly all kinds of organic matter. In highly reducing environments bacteria tend to convert the organic remains of plants and animals into substances which are more petroleum-like. This they do by splitting oxygen, nitrogen, sulfur and phosphorus from various organic compounds. This is illustrated by the data given in Table 1 on the average proximate chemical composition of the organic content of sediments of increasing antiquity.

TABLE 1

Type of material	Carbon Per cent.	Hydrogen Per cent.	Oxygen Per cent.	Nitrogen Per cent.
Marine sapropel	52	6	30	11
Recent sediments ..	58	7	24	9
Ancient sediments ..	73	9	14	3
Crude oil	85	13	0.5	0.4

Sapropel consists largely of the recently deposited remains of marine plants and animals. A large part

of it is decomposed prior to burial. The organic content of now exposed ancient sediment is less than the organic content of recent sediments. The lost organic matter has probably been oxidized to carbon dioxide and water. There is no proof that bacteria are responsible for the changes in the quantity and quality of the organic content of sedimentary material, but the occurrence of bacteria in the sediments which are potentially capable of such transformations is highly significant. Similar reductions in the total quantity and in the oxygen, nitrogen, sulfur and phosphorus content of organic matter incubated anaerobically for a few months have been observed in the laboratory where no such changes occurred in sterile controls. Several of the mechanisms are well known whereby bacteria deoxygenate certain kinds of organic matter (decarboxylation), reduce its nitrogen content (ammonification) or remove sulfur (hydrogen sulfide production).

While it is not to be implied from the aforementioned laboratory experiments that bacteria produce petroleum from organic matter independent of other agencies, it is significant that the bacterial formation of hydrocarbons has been demonstrated. In a recent series of experiments 34 mgm of ether-soluble, unsaponifiable, oil-like material was recovered from a culture enriched with 1.2 grams of caproic acid as the only carbon source. Determinations of the refractive index, bi-refringence, optical activity and carbon and hydrogen content of this oil-like material indicated that it consisted largely of normal paraffins ranging from $C_{20}H_{42}$ to $C_{25}H_{52}$. In other extracts from bacterial cultures was found a material indistinguishable from the ceresin waxes of crude oil. Repetitions of the experiment have shown that certain sulfate-reducing bacteria isolated from petroliferous sediments produce small quantities of oil-like extracts from acetic, propionic, butyric, capric, stearic and lactic acids. Though not proposed as an answer to the origin of oil, these experiments establish that sulfate-reducing bacteria can convert certain kinds of naturally occurring organic matter into petroleum hydrocarbons under environmental conditions resembling those in which petroleum is believed to have been formed.

The evolution of methane during the bacterial fermentation of organic matter is common knowledge. Possibly ethane and propane in much smaller quantities are produced along with the methane. The bacterial production of carotene, leprotene, flavorhodin and other complex pigmented hydrocarbons has been reported. The liberation of benzene from the bacterial decomposition of the amino acid tyrosine has also been reported. Theoretically other aromatic hydrocarbons of the benzene series could result from bacterial decomposition of organic materials containing carbon-ring components.

Certain theories of petroleum formation require the copious evolution of hydrogen. As is pointed out, though, by a leading petroleum geologist late in 1942, "Because we have uniformly failed in the past to find the requisite hydrogen within the earth's crust, the theory remains unproved." Looking into the little explored microbiological realms for an explanation, we find that the anaerobic fermentation of organic matter may result in the liberation of appreciable quantities of hydrogen. In experiments conducted in the S.I.O. laboratories recently, it has been observed that as much as 60 per cent. of the gas (by volume) resulting from the fermentation of glycerol by marine anaerobes consisted of hydrogen. Large quantities of hydrogen are also liberated from cellulose and proteinaceous substrates. In the presence of other types of bacteria no free hydrogen may appear because (1) it may be activated to unite with carbon dioxide with the production of methane:

$$CO_2 + 4H_2 = CH_4 + 2H_2O$$

(2) certain bacteria may cause the hydrogen to reduce sulfates to hydrogen sulfide:

$$SO_4^{--} + 5H_2O = H_2S + 4H_2O$$

or (3) bacteria may actuate the hydrogenation of unsaturated organic compounds. All three reactions are known to be catalyzed by anaerobic bacteria which occur in marine sediments. Consequently, in such marine sediments one would expect to find the reduction products (methane, hydrogen sulfide or saturated hydrocarbons) rather than free hydrogen. It may be significant in this regard that unsaturated compounds are not found in petroleum.

Many kinds of bacteria provoke the direct transfer of hydrogen from one compound to another. Possibly it is by such a mechanism that lipoclastic anaerobes have demonstrated tendencies toward the reduction and the decarboxylation of fatty acids.

Hydrogen sulfide, which is produced in large quantities by sulfate-reducing and protein-decomposing bacteria, may play a role in the reduction of organic matter to hydrocarbons. The following is a hypothetical example of a reaction which is thermodynamically possible in a highly reducing environment:

$$C_6H_{12}O_6 + 7H_2S = C_6H_{14} + 6H_2O + 7S$$

Some such reaction may account for the observed diminution of the sulfide content in a closed system of anaerobes growing on carbohydrates and proteins. Bacterially produced hydrogen sulfide may favor petroleum formation by creating reducing conditions.

Reducing conditions promote the formation and favor the preservation of petroleum hydrocarbons. The oxidation-reduction potential of marine bottom deposits is as low as E_h −0.2 to −0.5 volts in areas

where there is considerable deposition of organic matter. Measurements on profile series show that the sediments become more reducing from the surface downward to a depth of several feet, where the oxidation-reduction potential is uniformly low. Oil-bearing sediments are generally highly reducing, a condition for which bacterial activity may be largely responsible. It has been demonstrated in the laboratory that raw cultures of bacteria taken from marine sediments are able to create in simulated source sediments oxidation-reduction potentials more reducing than $E_h - 0.5$ volt.

Perhaps one of the most important functions of bacteria in the origin of oil is the desorption or release of oil from sedimentary materials. There are several mechanisms by which bacteria liberate oil from oil-bearing sediments. One of the most obvious mechanisms is the dissolution of carbonates by carbonic and organic acids produced by bacteria. When limestone, dolomite or other calcareous materials are dissolved, the oil associated therewith is liberated, and at the same time void spaces or channels are formed which provide for the migration or accumulation of oil. Carbon dioxide produced by bacteria either as a normal product of respiration or from the dissolution of carbonates tends to decrease the viscosity of oil, thereby promoting the movement or flow of oil. By increasing the internal gas pressure, carbon dioxide produced by bacteria *in situ* tends to drive oil from dead-end pockets and through interstitial spaces.

Certain thigmotactic bacteria release oil from non-calcareous sediments. By virtue of the affinity of such bacteria for solid surfaces on which they grow, oil is crowded off. Some of the bacteria produce detergents or surface-active substances which liberate oil from solid surfaces. "Light ends" released by any of the aforementioned mechanisms dissolve heavier hydrocarbons and promote the flow of oil. As will be elaborated below, some bacteria tend to decrease the density of crude oil, probably by splitting methane or other simple hydrocarbons from more complex molecules. It is believed that the action of bacteria in past geological ages has played an important part in the migration and accumulation of petroleum. Whether the oil is still locked in shales, tar sands or other oil-bearing materials or is in a fairly free-flowing state in subterranean structures, may have been determined largely by bacterial activity. The nature of the latter would be determined by the physiological types of bacteria which happened to be present and the prevailing environmental conditions.

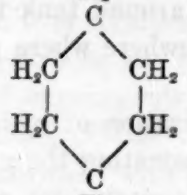
The release of oil from plants is another function attributed to bacteria. Most plants synthesize hydrocarbons to some extent, and some, such as the rubber tree, guayule plant, Russian dandelion, candelilla plant and milkweed, produce appreciable amounts of hydrocarbons. The selective decomposition of the plant proteins and carbohydrates following the death of the plant may release the hydrocarbons for eventual accumulation in sediments. Of course, whether the hydrocarbons also will be destroyed by bacteria will depend upon the types of bacteria present and the environmental conditions.

Although generally regarded as biologically inert, most kinds of petroleum hydrocarbons ranging from simple gases to complex solids are susceptible to oxidation by bacteria under certain conditions. Methane, petroleum ether, gasoline, kerosene, lubricating oil, paraffin wax, tars, benzene, xylene, anthracene, naphthalene, mineral oil and cyclohexane are among the common hydrocarbons which are attacked by bacteria. Half a hundred species of microorganisms representing more than a dozen different genera have been shown to utilize one or more kinds of hydrocarbons. Such microorganisms appear to be quite widely distributed in marine sediments. They are particularly abundant in the soil around tank farms, oil wells, leaky gas mains and elsewhere where petroleum or its products are spilled.

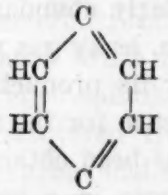
Evidence for the microbial utilization of hydrocarbons has been obtained by demonstrating the growth of bacteria in a medium which contains no carbon or energy source except pure hydrocarbons, by measuring oxygen consumption and carbon dioxide production in such a medium, and by observing changes in the hydrocarbons. Since most hydrocarbons are virtually insoluble in water, it is necessary to disperse them in order to provide for their ready attack by bacteria. Some degree of success has been enjoyed by emulsifying the hydrocarbons, but the best results have been obtained by dispersing the hydrocarbons adsorbed on solid surfaces such as asbestos fibers, glass wool, silica sand or diatomaceous earth. With the exception of one anaerobic organism, all known bacteria which oxidize hydrocarbons require free access to atmospheric oxygen. Representatives of the following genera have been credited with the ability to oxidize hydrocarbons: *Pseudomonas, Micrococcus, Mycobacterium, Actinomyces, Bacillus, Bacterium, Corynebacterium, Sarcina, Serratia, Spirillum, Aspergillus, Penicillium, Monilia* and *Micromonospora.*

Although there is a high degree of specificity in the types of hydrocarbons attacked by individual microbial species, certain tentative generalizations can be made. These generalizations are based upon observations on the behavior of enrichment cultures grown in the presence of about a hundred pure hydrocarbons and a score of "narrow cuts" or refinery products. As a rule, aliphatic or paraffinic compounds

are oxidized more readily than corresponding aromatic or naphthenic compounds. Long-chain hydrocarbons are more susceptible to bacterial oxidation than those of shorter chain length. For example, when similarly dispersed in mineral solutions, paraffin wax is utilized more readily than lubricating oil. Then follows kerosene, gasoline, low-boiling-point petroleum ether and natural gas. There are relatively few organisms which can oxidize methane (CH_4), and it only with difficulty. Oxidized with progressively increasing ease are propane (C_3H_8), hexane (C_6H_{14}), octane (C_8H_{18}), decane ($C_{10}H_{22}$), hexadecane ($C_{16}H_{34}$) and dicetyl ($C_{32}H_{66}$). Branched chain hydrocarbons or iso-compounds are oxidized by bacteria more readily than normal or straight chain homologs. Unsaturated compounds containing double bonds are oxidized more readily than the corresponding saturated compounds in the aliphatic series. However, cyclohexane, which has no double bonds, is more susceptible to bacterial oxidation than benzene:



Cyclohexane



Benzene

It may be of interest to point out in passing that rubber hydrocarbons, both natural and synthetic, are attacked by a large number of microorganisms. Pure natural rubber or caoutchouc, which has the composition $(C_5H_8)_n$, is more susceptible to microbial oxidation than compounded rubber products. In the absence of inhibitors, buna-N, buna-S and butyl rubbers are all readily attacked by bacteria when dispersed in appropriate mineral solutions. Thiokols A, B and FA, which differ markedly in chemical composition from other synthetic rubbers, are relatively resistant to microbial attack.

Hydrocarbon-oxidizing bacteria may be of considerable importance in the petroleum picture: (1) Such organisms may prevent the accumulation of oil in any environment except where conditions are inimical to their activity. Thus in seeking the origin of oil we should look for factors which inhibit the activity of hydrocarbon-oxidizing microorganisms. Some of the factors which are known to be inhibitory are hydrogen sulfide, low oxidation-reduction potentials and certain heavy metals.

(2) There is some evidence that hydrocarbon-oxidizing bacteria may alter the properties of crude oil by attacking preferentially long chains or branched chains, by splitting methane and perhaps other simple hydrocarbons from more complex compounds, or by attacking preferentially compounds containing oxygen, nitrogen or sulfur. A decrease in the density of a small sample of crude tar from 1.02 to 0.94 during six months' incubation has been shown to be due to the action of bacteria.

(3) The rapid disappearance of oil pollution in waterways, around refineries, pipe-line leaks, oil seepages, along beaches where there is drilling, and elsewhere where oil is spilled in water or on the soil is believed to be due largely to the activity of hydrocarbon-oxidizing bacteria. This seems to be Nature's way of "pulling the chain" for the disposal of oil which otherwise would pollute fields and waterways.

(4) Hydrocarbon-oxidizing bacteria may contribute to the formation of "paraffin earth" which is quite commonly found in surface soil overlying subterranean deposits of petroleum. Certain samples of so-called "paraffin earth" have been found to contain large numbers of hydrocarbon-oxidizing bacteria or their refractory remains.

(5) Large numbers of bacteria which oxidize volatile hydrocarbons, including ethane, propane and butane, are found in surface soil surrounding or overlying oil fields. The demonstration of these bacteria or their fossil remains in surface soil in definite distribution patterns is the basis of so-called "geomicrobiological" prospecting methods. Although nature generally hides her treasures well, she usually leaves a clue, which in this case may be the fossil remains of hydrocarbon-oxidizing bacteria. The perfection of a technique for the rapid identification of such fossils in the field may provide another tool to aid in the search for oil.

(6) The whimsical behavior of hydrocarbon-oxidizing bacteria sometimes results in confusion in the search for oil by "soil analysis" methods of prospecting. Volatile hydrocarbons in soil samples collected for analysis may be destroyed quantitatively within a few hours by bacteria, if conditions are conducive to the activity of such bacteria, resulting in negative or anomalous findings. The failure of various workers to find petroleum hydrocarbons in recent sediments may be due to the increased activity of hydrocarbon-oxidizing bacteria following the collection, transportation and storage of the samples.

(7) Microorganisms which attack hydrocarbons are sometimes instrumental in causing undesirable changes in petroleum products stored over water. The discoloration of refinery products and the formation of gummy substances have been traced to the activity of hydrocarbon-oxidizing bacteria. This also applies to observed decreases in the octane rating of aviation gasolines which in certain emergencies and experimentally have been stored over water.

The action on aviation gasolines is threefold: (a) Branched-chain hydrocarbons which have the highest anti-knock characteristic are preferentially attacked with the liberation of some methane, (b) microbially produced sulfides precipitate tetraethyl lead, and (c) peroxides produced by the bacteria catalyze the deterioration of tetraethyl lead.

(8) There is a report in the literature which ascribes an explosion of a kerosene tank to the production of a mixture of methane and hydrogen from the bacterial decomposition of kerosene in water storage.

(9) The growth of hydrocarbon-oxidizing bacteria in medicinal and pharmaceutical preparations having hydrocarbon bases has resulted in discolored and otherwise altered products. Allergies have been traced to the use of such products. Cooling oils have also been unfavorably affected by the profuse growth of hydrocarbon-oxidizing bacteria.

Little is known regarding the end-products which result from the bacterial utilization of hydrocarbons, except that carbon dioxide and bacterial protoplasm are always produced. There are reports in the literature on the production of methane, hydrogen, ketones, aldehydes, alcohols and organic acids. The products of metabolism will depend upon the bacterial species, the hydrocarbons and the experimental conditions. The observation that fatty acids result from the bacterial oxidation of petroleum hydrocarbons suggests exploring the possibilities of using microbial catalysts to convert hydrocarbons into much needed edible fatty acids. More extensive and intensive studies on the products of hydrocarbon utilization can be expected to yield interesting information on bacterial physiology.

In conclusion and to clarify my own views on the subject, it should be emphasized that while bacteria probably play an important role in the formation and transformation of petroleum, geological, geophysical and geochemical factors are also believed to be of importance in the origin of oil. The bacterial synthesis of certain petroleum hydrocarbons has been demonstrated, but it seems doubtful if it will ever be practical to produce by bacteria any hydrocarbons except methane on a commercial scale. The fondest hope for the future now entertained is that intensified microbiological studies coupled with other investigations on the origin of oil may eventually provide information which will aid in the discovery of existing pools of petroleum. Geomicrobiological prospecting and refined methods of "soil analysis" may prove to be a step in this direction. Microbiological processes may find practical applications in the petroleum industry, the most promising of which appears to be the use of bacteria in the recovery of petroleum from oil-bearing materials, in certain refinery processes and in the disposal of various waste products. Wherever petroleum or its products are stored in contact with water, the possible effects of hydrocarbon-oxidizing microorganisms must be taken into account. The multiple effects of bacteria on the formation and transformation of petroleum hydrocarbons is a new frontier of learning which presents a challenge to the petroleum industry and to the microbiologist.

OBITUARY

EDMUND BURKE DELABARRE

EDMUND BURKE DELABARRE, one of the pioneers of American psychology in the days when it was transforming itself into an experimental science, died in Providence on March 16, 1945. He was born in Maine in 1863. His influential teachers were Garman at Amherst, James at Harvard and Münsterberg at Freiburg, where he obtained the Ph.D. in 1891. He established the psychological laboratory of Brown University in 1892 and remained there as active professor for forty years and as emeritus (but still active) for the remaining years of his long life. His investigations were principally concerned with vision and with muscular movement and the sensations of such movement. An ingenious apparatus man, he designed pieces for continuous registration of respiratory and circulatory movements (as in emotion) and of automatic hand movements. He was the first, in 1898, to obtain an objective record of eye movements, and his method of mechanical registration, though soon superseded by photographic methods, gave accurate and important results. He attacked the difficult problem of explaining how the visual field can be transformed from a mere aggregate of color patches into a well-organized field of objects in space, and showed that a fairly comprehensive theory could be based on sensations of tension in the eyeball muscles. His work on this problem and others has not been fully published. As an avocation he did much intensive work in New England archeology and is especially noted for his decipherment of the famous "Dighton Rock." Dr. Delabarre was a man of sparkling eyes and cheerful disposition and of wide interests, a man whom it was always a pleasure to encounter.

R. S. WOODWORTH

FRANK W. COLLIER

DR. FRANK W. COLLIER, formerly dean and professor of philosophy at the Graduate School, American

University, Washington, D. C., died on August 31. He was born at Elliott's Mills, Maryland, on January 5, 1870. He was educated at the Johns Hopkins University, from which he was graduated A.B. in 1896, and at Boston University, where he received the degree of S.T.B. in 1899. Following his ordination to the Methodist Episcopal ministry, he served as pastor to several churches in Massachusetts, meanwhile pursuing graduate work at Boston University under the eminent American philosopher, Borden P. Bowne, being graduated Ph.D. in 1910.

With the organization of the curriculum at the American University in 1914, Dr. Collier was called to take charge and served as dean of the Graduate School and professor of philosophy until 1928, when he relinquished the deanship, retaining the chair of philosophy. He retired from active teaching in 1936.

Dr. Collier's courses in philosophy were of unusual appeal to the scientific students at the Graduate School. He was broadly versed in the literature, history and method of science and had a deep and competent grasp of fundamental scientific principles. His discussions of the foundations of scientific knowledge were revelations to his students, developing new concepts and presenting points of view of great educational value. Collier's approach to a problem was liberal and receptive. His appeal was ever to the intellect; mere authoritarianism he detested. After a course with Collier the scientific student could be called educated as well as trained.

Dr. Collier rendered a service to biology and biologists at the time of the assault on the teaching of evolutionary theories during the middle 1920's. His book, "John Wesley among the Scientists," described the evolutionary opinions of that divine and was credited with persuading the Methodist Episcopal Church to withhold support from the fundamentalist cause.

A generation of students mourns his passing.

JAMES F. COUCH

ERMON DWIGHT EASTMAN

DR. ERMON DWIGHT EASTMAN, professor of chemistry at the University of California, died suddenly on May 19 following a heart attack. He was fifty-three years old. He had been associated with the University of California since 1917, the year in which he received his Ph.D. from that school. In 1932–33 he held a Guggenheim Memorial Fellowship for research at the University of Munich.

Dr. Eastman made many outstanding contributions in the field of chemical thermodynamics. By experimental data and theoretical considerations he aided in the exact statement of the third law of thermodynamics. His research on the specific heat of hydrogen at low temperatures gave a highly important experimental value. He called attention to the entropy of transfer in electrolytic cells, a quantity which had not been recognized, and his work on thermal cells gave values for the absolute entropies of the aqueous ions which is noteworthy as one of the few reasonably accurate absolute values for any property of a single ion in solution. He also published a number of papers relating to the structure of the atomic nucleus.

At the time of his death Dr. Eastman was director of a war research program for the Army.

W. M. LATIMER

RECENT DEATHS

DR. HERBERT EUGENE WALTER, professor of biology, emeritus, of Brown University, died on October 1 at the age of seventy-eight years.

DR. W. S. DYER, associate professor of physical chemistry in the University of Arkansas, died on September 27 at the age of forty-four years.

DR. HERBERT O. CALVERY, for the past nine years chief of the division of pharmacology of the Food and Drug Administration, Federal Security Agency, died on September 23. He had been directing also a number of research projects under the auspices of the Office of Scientific Research and Development.

DR. P. DEL RIO HORTEGA, formerly director of the Instituto Nacional del Cancer at Madrid, and more recently head of the laboratory of histology and histopathology at Buenos Aires, died on June 1 at the age of sixty-three years.

SCIENTIFIC EVENTS

THE SPRING MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

UPON the removal of restrictions on the holding of conventions by the Office of Defense Transportation, the officers of the association at once began to explore the possibilities of holding a meeting during this coming winter or spring.

After an extended investigation of the possibilities, it has been decided to hold a general meeting of the American Association for the Advancement of Science in St. Louis, Missouri, in the period March 27–30, 1946. A conference of the secretaries of the sections of the association and of the principal affiliated societies who live in the East will be held at the Pennsylvania Hotel in New York City at 10 o'clock A.M., on

October 14, for the purpose of discussing plans for the St. Louis meeting; a similar conference of the secretaries who live in the Middle West will be held at the Stevens Hotel, Chicago, at 10 o'clock A.M., on October 21.

F. R. MOULTON,
Permanent Secretary

EXPEDITION TO NYASALAND OF THE AMERICAN MUSEUM OF NATURAL HISTORY

THE American Museum of Natural History, New York, has announced plans for its first large-scale expedition abroad since 1941.

Arthur S. Vernay, trustee of the museum, who has sponsored numerous expeditions to remote parts of the world for the past twenty-five years to collect material for exhibition and research, will lead an expedition to Nyasaland, South Africa, next April, where it is planned to make extensive collections of mammal and plant life. His last expedition for the museum, with Lieutenant Colonel C. Suydam Cutting and Dr. Harold E. Anthony, was in northern Burma in 1939, a few months prior to the war.

Members of the expedition will include Dr. Harold E. Anthony, chairman and curator of the Department of Mammals; Leonard Brass, botanist, and Captain Guy Shortridge, director of the Kaffrarian Museum of King William's Town, South Africa.

Dr. Anthony will represent the museum in the study of the mammals collected. Unless some very unusual specimen of large game is encountered, the energies of the party will be devoted to the intensive study of the smaller and less conspicuous fauna.

The native plants of Nyasaland are little known. Mr. Brass, who accompanied the Richard Archbold Expeditions to New Guinea, which in 1939 discovered the hidden "Shangri-La" Valley, will collect herbarium and living botanical specimens. This material will go to the New York Botanical Garden, which is cooperating in the project.

The expedition will be in the field for five months, working during the dry season, from May to October of 1946. A complete record in motion picture and color photography is planned in conjunction with the collecting work. Trained natives will assist in hunting and in the preparation of material.

PREDOCTORAL FELLOWSHIPS IN THE NATURAL SCIENCES

THE National Research Council announces that it is now ready to receive nominations and applications for the predoctoral fellowships in the natural (*i.e.*, mathematical, physical and biological) sciences which it is administering under a grant from the Rockefeller Foundation. These fellowships are intended to assist young men and women, whose graduate study has been prevented or interrupted by the war, to complete their work for the doctorate. It is hoped that these fellowships will do much to accelerate the recovery of the scientific vigor and competence of the country which is so seriously threatened by the loss of almost two graduate school generations of scientifically trained men and women.

This program will be administered by a Committee on Predoctoral Fellowships of the National Research Council whose members are Henry A. Barton, Charles W. Bray, Detlev W. Bronk, Luther P. Eisenhart, Ross G. Harrison (chairman—National Research Council, *ex officio*), W. A. Noyes, Jr., and John T. Tate, *chairman;* Enid Hannaford, *secretary.*

The annual stipend will be $1,200 for single persons and $1,800 for married men. In general it is expected that each recipient will spend at least eleven months per year on academic work. An additional allowance up to $500 per year will be made for tuition fees. Fellowships granted to individuals who are eligible for educational support from the "G.I. Bill of Rights" will be at such stipends as to bring the total income from these two sources to that which would be received at the above rates.

Each fellow, before entering on his graduate studies, will submit for review by the Committee on Predoctoral Fellowships a schedule, approved by the dean of his graduate school, for the completion of his work for the doctorate. This schedule, as approved by the committee, will constitute an informal agreement upon the basis of which stipend payments will be made. At the discretion of the university concerned the fellowship stipend may be supplemented by university grants. All such supplementary sources of income should be made a matter of record with the committee. The progress of the fellows will be subject to periodic review by the committee which reserves the right to cancel fellowships when in their judgment satisfactory progress is not being maintained.

Prospective candidates for these fellowships are urged to apply at once even though they may be unable to undertake their graduate study in the immediate future. Information concerning the fellowships and nomination-application blanks are being mailed out widely to graduate schools and wartime research laboratories. They may also be obtained by writing directly to the Secretary, Committee on Predoctoral Fellowships, National Research Council, 2101 Constitution Avenue, N.W., Washington 25, D. C.

NEWS FROM ABROAD

ASSISTANT PROFESSOR EDWARD A. STEINHAUS, of the University of California, writes:

Readers of SCIENCE may be interested in the following fragmentary information concerning Dr. A. Paillot,

French scientist well known for his studies on the microbiology of insects and for his book "L'Infection chez les Insectes." He was Directeur de la Station de Zoologie Agricole du Sud-Est, at Saint-Genis-Laval (Rhône).

Dr. Paillot died suddenly of cerebral hemorrhage on December 23, 1944. To a large extent he was able to carry on his research during most of the German occupation of France. His youngest son was arrested, taken from the country, and held in a prison camp. This, together with the uncertainties concerning the welfare of his other children, probably did much to hasten his death.

I received this information a few days ago from his wife, Madam Paillot, who said that although the period of occupation was trying, her husband never gave up hope that liberation would come.

Dr. E. W. Lindstrom, professor of genetics at Iowa State College, has transmitted to SCIENCE the following letter, dated June 1, from Professor Adriano Buzzati-Traverso, Instituto Italiano di Idrobiologia, Verbania Pallanza:

I take the first chance offered me to let you have my news after this long and terrible war by means of the kindness of the local American Civil Affairs Officer (Major Maurice R. Brown). At the beginning of 1941 I was sent with my regiment to Libya. I was sent back because of illness and on recovery went to my work at the University of Pavia. . . .

I worked for 5 months in 1942 at Timofeeff-Ressowsky's Institute for Public Health in Rome until June, 1943, publishing several papers in Italian scientific journals. . .

At the time of Italian armistice and German invasion, I was home in Belluno. Later I went back to Pavia to save the laboratory. I transported scientific materials, books, apparatus and cultures to Pallanza, wherefrom I am now writing. In such a way I succeeded in saving a collection of more than 200 living stocks of Drosophila which I think is the only one surviving in continental Europe, with the exception of Russia.

As you know the Italian situation in the field of biology was bad even before the war and since it has become even worse with the destruction of many university laboratories and libraries. The new Italian government is now facing more urgent problems than the reorganization of universities. . .

The most urgent need is to get acquainted with scientific production of the Allied Nations during the last five years. We need to have here books and journals. . . . To modernize Italian biology we are starting publication of short books, dealing with modern biology. We need also suggestions on books or general articles which you judge worthy of translation.

Dr. E. D. Merrill, director of the Arnold Arboretum of Harvard University, writes that he has just received a letter from a former staff member of the Berlin Botanic Garden, supplying certain definite information as to what happened to that institution in the bombing raids commencing on March 1, 1943 (see SCIENCE n.s. 98: 490–491. 1943).

The Botanical Museum was the first of the museums in Berlin to be hit by explosive and phosphorus bombs, this on the night of March 1. There was no possible defence against the very large fire and about 90 per cent. of the herbarium, the complete library, and the library of the Brandenburg Botanischer Verein that was stored in the building (20,000 volumes), and all manuscripts and technical papers in preparation were lost. In addition to the general herbarium, among the special collections lost were the Schweinfurth herbarium, the East African collections, the Clemens' Borneo collections, Weberbauer's Peruvian material, the Schlecter orchid herbarium, all the Chinese collections and all the private collections of staff members in the form of books, reprints, etc.

Among the material saved was all of the very large fern collection and some of the fungi, for this material had been transferred to the entrance hall for removal to a safer place. A certain amount of the material in the basement, mostly duplicates, and all the types of *Proteales, Santales* and *Rhoeadales* had been removed from the general herbarium some days before the catastrophe, as well as the complete and historically very important Willdenow herbarium; the opinion was expressed that most of the material on loan from foreign institutions was saved. The collections that were saved had been transferred to the abandoned galleries of a former salt mine near Bleicherode (Harz), this being located in what is now the Russian zone of occupation.

On February 15, 1944, the colonial wing of the main building, which contained important collections of wood, fruits and certain exhibition material, was struck by a phosphorus bomb and was utterly destroyed.

Dr. Merrill's informant states that when his correspondent returned to Berlin in June, 1943, for a short visit, he found the museum in ruins with no trace of his own scientific work remaining. During 1943 and 1944 the great palm house and other greenhouses were hit several times by heavy bombs and the garden became more and more devastated by numerous incendiary bombs, while the meadows were cut by trenches for civilian air defense. He states further that when he left Berlin in March, 1945, the institution was in a terrible condition.

Dr. Merrill observes that the destruction of the great basic collections of the herbarium material and literature in Berlin is by far the greatest botanical catastrophe of the war, and its loss will be reflected in future years in all countries where botanical work is prosecuted, because of the historical aspects of the collection.

Dr. P. L. LeComte du Noüy, of New York, writes to SCIENCE: "I have just received a letter from France informing me of the death of my friend and colleague, Professor Fred Vlès, of the University of Strasbourg.

"Dr. Vlès was imprisoned by the Germans in March, 1944, and died of hunger and exposure in the box car in which he was, as hundreds of others, shipped to Germany.

"Fred Vlès will be remembered as the greatest biophysicist in Europe, and as the founder and editor of the *Archives de Physique biologique*, of which seventeen volumes were published since 1921. His work on the physical chemistry of cancerous serum is of outstanding importance.

"The same letter also informs me of the heroic death of one of his coworkers, Dr. Reiss, medical officer of an F.F.I. resistance group, killed in action at Chaudesaignes.

"The *Archives* will go on, under the direction of a group of his associates: Professor Vellinger, Professor G. Achard, Dr. Gex and myself."

In a letter dated August 26, 1945, from Munich Dr. W. M. Hoehn, of Kansas City, received the following interesting letter concerning Dr. Wieland, director of the department of chemistry of the Ludwig-Maximilian University in Munich:

I did see Dr. Wieland of Munich—Dr. Geheimat Wieland, former head of the School of Medicine and an authority on hormones to which he gave most of his studies. His case is typical of many of the learned men of this defeated country; I am not saying the treatment was justified as I don't know the whole story, only words in his defense.

Dr. Wieland is a rather small man with a pleasing personality, quite modest and his hair is very sparse; he wears very heavy glasses. I saw him at Starnberg where his friends arranged a meeting with me. He said the authorities had deprived him of his books and would not permit him to work in his laboratory. He has been moved forcibly four or five times and now lives in a single room with his wife, who is a pleasant woman. It seems to be such a tragic ending to such a learned man—he is highly regarded in this city, every one knows him and those who attended the university and know him personally believe that he is being held under suspicion unjustly. I have heard the story from many sources, but it is best told by one of his students, a Belgian who has studied under him for five years. Briefly it is this: Dr. Wieland was to be given the Goethe Medaille für Kunst und Wissenschaft from the Nazis for his work. He did not wish to accept it as he was not in sympathy with the Nazis' uses of his discoveries and teachings. It was either accept or go to prison; his friends urged him to accept because much of his work was yet to be done and he could continue. The honor was accepted and he became tied up with the National Socialists.

Most of his time is spent now with his wood cutting and winter is coming on.

Dr. Wieland has done a great deal to present basic facts about bile acids, sterols and the opium alkaloids. The fundamental research which has been done in his laboratories has done much toward establishing the structures of these compounds. It is most unfortunate, indeed, that he can not continue work in this field and contribute to the store of fundamental knowledge.

It is instances of this type that will create the great intellectual desert in the European universities. The results will eventually affect the university and industrial life in the United States, since a great deal of the fundamental knowledge was formerly derived from the European universities. Men of Dr. Wieland's caliber are still able to make great contributions to the field of science which will work for universal good.

SCIENTIFIC NOTES AND NEWS

A DINNER was given on October 3 at the Faculty Club of Harvard University in honor of Dr. C. T. Brues, professor of entomology, on the occasion of his retirement with the title emeritus. There was an attendance of eighty. A bound book, containing letters of appreciation and a silver bowl were presented to him. Dr. F. M. Carpenter, who will succeed Dr. Brues as professor of entomology, presided.

THE Remington Gold Medal, conferred each year for work during the preceding year, or culminating over a period of years, judged most important to American pharmacy, has been awarded to Joseph Rosin, pharmaceutical chemist of Plainfield, N. J., in recognition of "contributions to scientific pharmacy and the development of drug standards for protection of the public." The medal commemorates Joseph P. Remington, the nineteenth century pharmacist who made many contributions to research, education and pharmaceutical literature. In naming Mr. Rosin to receive the medal, the committee on award cited him as "the foremost American authority on chemical reagents."

PROFESSOR HENRY C. SHERMAN and Mrs. Sherman gave on September 25 a luncheon at the Men's Faculty Club of Columbia University in honor of Dr. H. Louise Campbell, who is retiring from her research work in food chemistry.

DR. D. ROBERT YARNALL, president of the Yarnall-Waring Company of Philadelphia, has been elected president of the American Society of Mechanical Engineers for 1945–46.

DR. WILLIAM S. HALL, now eighty-four years old, a member of the faculty of Lafayette College for sixty-one years, has presented his resignation. Dr. Hall, who was head of the department of mathematics, retired in 1934 after serving for fifty years, but he remained clerk of the faculty.

IN a note in the issue of SCIENCE for September 28, p. 325, it is stated that Charles E. Lawall had resigned as president of the University of Virginia. This should read the University of West Virginia.

DR. CHARLES F. DEISS, professor and head of the department of geology at Montana State University, has been appointed State Geologist of Indiana, and professor of geology and head of the department of geology and geography at Indiana University.

DR. CARL L. SIEGEL has been appointed to a professorship in the School of Mathematics of the Institute for Advanced Study, of which he has been a member since 1940. He is of German nationality and left his professorship in Göttingen in 1940 because of his opposition to the Nazi regime. Previously he had lectured in Hamburg and had held a professorship at Frankfurt-am-Main.

DR. ANTONI ZYGMUND, one of the leading mathematicians in the field of trigonometric series and a recipient of the Prize of the Polish Academy of Sciences in 1939 for mathematical research, has been appointed professor of mathematics at the University of Pennsylvania. In 1939–40 he was a visiting lecturer at the Massachusetts Institute of Technology. He will join the university in November and will teach classes at both the undergraduate and graduate levels.

DR. C. S. GROVE, JR., for the last four years in the Rayon Department of the E. I. du Pont de Nemours and Company at Buffalo, N. Y., has been appointed professor of chemical engineering at the State University of Iowa.

PROMOTIONS in the sciences of members of the faculty of the Case School of Applied Science, Cleveland, are: To professorships: Dr. Orley E. Brown, mathematics; Dr. Samuel H. Maron, physical chemistry; Dr. Clark O. Miller, chemical engineering; to associate professorships: Dr. Eugene C. Crittenden, physics; Dr. Charles C. Torrance, mathematics; Dr. William von Fischer, chemistry, and Dr. Leonard O. Olsen, physics. Dr. Paul E. Guenther has been made assistant professor of mathematics.

DR. IVAN A. GETTING has been appointed associate professor in the department of electrical engineering of the Massachusetts Institute of Technology. During the war he was head of a division of the Radiation Laboratory at the institute and directed research and development in the general field of the applications of radar to gunnery and associated problems.

DR. LOTHROP SMITH has returned to his work in the division of analytical chemistry at the State University of Iowa after an absence of two years when he was engaged in research work at the laboratory of metallurgy of the University of Chicago, and at Oak Ridge, Tenn.

DR. CARROLL C. PRATT, head of the department of psychology at Rutgers University, has been granted leave of absence to accept an appointment as professor of psychology in the Institute of Philosophy, University of Ankara, Turkey. Dr. Muzafer Sherif, professor of psychology at the University of Ankara, is at present in this country on a two-year fellowship granted by the U. S. Department of State. Professor Pratt will be accompanied by Mrs. Pratt, who has been requested by the Department of State to assist her husband in the study of the history and practice of Turkish music.

DR. RODERICK A. BARNES, formerly instructor and research fellow in chemistry at the University of Minnesota, has been appointed instructor in organic chemistry at Columbia University.

DR. ROBERT E. BUCKLES has been appointed instructor in organic chemistry at the State University of Iowa. For the past two years he has been engaged in work for the National Defense Research Committee at the University of Minnesota.

DR. W. D. TURNER, since 1929 a member of the department of chemical engineering of Columbia University, has resigned to become technical director of Florida Chemical Research, Inc. and Airkem, Inc., manufacturer of the chlorophyll air freshener.

DR. L. W. ROTH, formerly assistant professor in the department of physiology and pharmacology of the University of Colorado Medical School, has joined the department of pharmacology of the Abbott Laboratories in North Chicago.

DR. TORBJOERN CASPERSSON, of Stockholm, and Dr. K. Linderstroem-Lang, of Copenhagen, have arrived in the United States. They are the guests of the Jane Coffin Childs Memorial Fund and the International Cancer Research Foundation. They plan to attend the Conference on Intracellular Enzymes in Normal and Malignant Tissues which is sponsored jointly by these two organizations.

DR. GILBERT STORK joined on August 27 the scientific staff of Lakeside Laboratories, Inc., Milwaukee, in the capacity of senior research chemist.

ROY INNES, since 1939 a member of the Operational Research Section attached to Fighter Command of the R.A.F., has been appointed general secretary of the British Association of Scientific Workers.

DR. WALTER H. BUCHER, professor of structural geology at Columbia University, is now in Venezuela at the invitation of the Venezuelan Government. In cooperation with Dr. Victor Lopez, of the Venezuelan Geological Survey, Dr. Bucher is engaged in the preparation of a tectonic map of Venezuela which will follow the design of the recently published tectonic map of the United States, and is being pre-

pared through the coordinated efforts of the various oil companies operating in Venezuela and of the Venezuelan Government. The Geological Society of America, in cooperation with Dr. Lopez and the Venezuelan Geological Survey, plans to publish a memoir on the geology of Venezuela to include a large colored geological map of the country. The tectonic map will supplement this project.

THE National Research Council announces that fellowships in mathematics, astronomy, physics, chemistry, geology, paleontology, physical geography, zoology, botany, agriculture, forestry, anthropology and psychology will be available for the year 1946–1947. These fellowships are awarded as a rule to persons under thirty-five years of age who are citizens of the United States or Canada, and who have met all the requirements for the doctor's degree. Applications must be filed on or before December 31, on forms obtainable from the Secretary of the Fellowship Board in the Natural Sciences, National Research Council, 2101 Constitution Avenue, Washington 25, D. C. A handbook describing the fellowships —stipends, conditions and tenure—will be furnished upon request.

DR. EDWIN C. JAHN, professor in the pulp and paper department of the New York State College of Forestry at Syracuse University, has leave of absence to enable him to accept an appointment with the Auxiliary Foreign Service of the Federal Department of State. He will undertake a special study of commercial and economic developments in the pulp and paper industry of the northern European countries. Dr. Jahn will be stationed at Stockholm and will cover the northern European countries, particularly Sweden, Norway and Finland. He is familiar with the area, having studied the chemical and paper industries there during the war, also having held an American-Scandinavian Foundation Fellowship to Sweden some years earlier.

DR. F. D. KEIM has been granted leave of absence from his work as chairman of the department of agronomy of the University of Nebraska. He left Lincoln by plane to New York on July 1 and sailed on the *Queen Elizabeth* for Europe. He is now stationed in the American University in Biarritz, France. This university is one of the two Army University Centers which were established in Europe, the other being at Shrivenham in England. Courses are offered to American service men while waiting for return to the United States. Dr. Keim does not expect to return for approximately seven or eight months.

DR. JAMES A. SHANNON, director of Research Service, Third New York University Medical Division, the Goldwater Memorial Hospital, and associate professor of medicine at New York University College of Medicine, will deliver on October 25 the first Harvey Lecture of the current series at the New York Academy of Medicine. He will speak on "Chemotherapy in the Human Malarias."

DR. CHESTER S. KEEFER, Wade professor of medicine at the School of Medicine of Boston University, will address a joint meeting of the Institute of Medicine of Chicago and the Chicago Society of Internal Medicine on "Penicillin" at the Palmer House on Friday evening, October 26.

THE National Committee for Mental Hygiene will hold at the Waldorf-Astoria Hotel, New York City, on November 1 and 2 its thirty-sixth annual meeting. A registration of 1,500 or more is expected.

THE University of Tennessee has established a "University Research Council," with Dean Fred C. Smith as chairman, which will coordinate the work of the various research agencies of the university and will promote "an expanded program of research." The council is composed of sixteen representatives from all present research agencies and from a number of the university departments. It is planned to encourage research in all fields and to assist in the growth of the entire research program of the university. The principal functions of the council include the stimulation of a broad functional program of research, the coordination of research projects in progress and the promotion of the application of research findings to the industrial, social and economic problems of the state. The council will also serve as the official body through which gifts and grants-in-aid may be made to the university for research purposes.

A GIFT of $100,000 to the Georgia School of Technology at Atlanta is being utilized for the purchase of an A–C Network Calculator from the Westinghouse Electric Corporation. Plans are now being completed for an addition costing $150,000 to the Research Building to house the calculator. Based on the number of circuits and other units, it is believed that it is second only to the calculators of the General Electric in Schenectady, N. Y., and Westinghouse in Pittsburgh, Pa.

JAMES W. ROCKWELL, of Houston, Texas, has made a gift to aid the endowment of the Marvin Lee Graves fellowship in internal medicine. This fellowship, established by the children of Dr. Graves, is designed to assist a young physician of promise in special research and study in internal medicine. It is named in honor of Dr. Marvin Lee Graves, of Houston, professor emeritus of medicine at the University of Texas School of Medicine, Galveston.

A GIFT of $15,000 has been made by the Harshaw Chemical Co., of Cleveland, to Western Reserve University for the furtherance of research in inorganic chemistry. The fund will support two fellowships in a three-year program of research under the direction of Dr. Harold S. Booth, professor of chemistry.

SPECIAL ARTICLES

BACITRACIN: A NEW ANTIBIOTIC PRODUCED BY A MEMBER OF THE B. SUBTILIS GROUP[1,2]

IN the study of the bacterial flora of contaminated civilian wounds in the Presbyterian Hospital Unit (under the direction of the Subcommittee on Surgical Infections, National Research Council), it was found that at times organisms appeared on the blood agar plates following direct plating of the injured tissue that were not recovered from broth cultures made at the same time from the same material. This occurred most frequently when the broth cultures contained a large number of aerobic Gram-positive sporulating rods.

Many of these strains had some degree of inhibiting action on subsequent plantings of the Gram-positive cocci which appeared with them on the direct plate. One strain isolated from tissue debrided from a compound fracture of the tibia was particularly active. We named this growth-antagonistic strain for the patient, "Tracy I." When cell-free filtrates of broth cultures of this bacillus proved to possess strong antibiotic activity and to be non-toxic, further study seemed warranted. We have called this active principle "Bacitracin."

The antibiotic is formed when the strain is grown in shallow layers of tryptone broth, beef infusion broth, Savita or Amigen broth or in a synthetic medium. So far it has not been formed to any appreciable extent in submerged growth. The maximum titer is obtained if the antibiotic is harvested after three to five days incubation at 37° C. A heavy surface pellicle is formed, but the decanted medium contains the antibiotic which can be extracted with normal butanol and concentrated by steam distillation *in vacuo*. Further purification results in a grayish-white powder. It has not been obtained in the pure form to date.

"Bacitracin" is filterable through a Berkefeld or Chamberland filter. It is a neutral substance and is not precipitable from the original harvest by manipulating the pH. It differs in this respect from Gramicidin,[3] Subtilin[4] and Gramicidin S.[5] It can not be extracted by ether, chloroform, acetone or ethyl acetate. It is water soluble and withstands heating for 15 minutes at 100° C. without significant loss of titer. It does not hemolyze human or sheep's red blood cells in saline suspension. It is stable in acid solution, but unstable in alkaline solution above pH9. It resists digestion with pepsin or trypsin.

There have been no acute or delayed symptoms of toxicity when the relatively impure material, concentrated by butanol extraction to 50 to 100 times the potency of the original harvest, has been injected repeatedly by the subcutaneous or intraperitoneal routes (mice, guinea pigs) or by the intravenous route (rabbits). There has been no sign of local irritation when such preparations were injected subcutaneously into human volunteers or when applied locally to human infections or on the human conjunctiva. Blood levels have been obtained following human subcutaneous injections.

A standard "unit" for assaying potency has not yet been established. It has been convenient to designate as one "unit" the amount which when diluted 1:1024 in a series of two-fold dilutions in 2 cc of beef infusion broth, completely inhibits the growth of a stock strain of Group A hemolytic streptococcus when the inoculum used to seed the tubes is 0.1 cc of a 10^{-2} dilution of an overnight culture in blood broth. The original harvest contains as a rule two to four units per cc. Material has been obtained which assayed ten units per cc when harvested from a synthetic medium. Table 1 gives the dilutions of one unit which result in complete bacteriostasis of some of the organisms which have been tested under suitable experimental conditions.

TABLE 1

BACTERIOSTATIC ACTION OF "BACITRACIN"

Organisms	Dilutions of 1 unit giving complete bacteriostasis
B. hem. streptococcus	
Groups A, B, C, G	512–1024
Group D	16–64
Nonhemolytic streptococcus	0–64
Pneumococcus	
Types I, II and III	512–1024
Staphylococcus aureus	16–64
Other Gram-positive micrococci	16–256
C. welchii	512–768
C. septicum	512
C. sordellii	512
C. histolyticum	128
C. sporogenes	256

[1] Preliminary report.

[2] The work described in this paper was done under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and Columbia University.

[3] R. J. DuBos, *Jour. Exp. Med.*, 70: 1–10, July, 1939.

[4] E. F. Jansen and D. J. Hirschmann, *Arch. Biochem.*, 4: 297–309, July, 1944.

[5] G. F. Ganse and M. G. Brazlini Kova, *Am. Rev. Soviet Med.*, 2: 134–148, December, 1944.

The action of "bacitracin" on additional species has been ascertained through use of the blood agar plate-penicylinder method. When *C. novyi* was the test organism, the zone of inhibition obtained was comparable to that with *C. histolyticum*. Certain strains of anaerobic nonhemolytic streptococcus were inhibited to the same extent as beta hemolytic streptococcus. Other strains were more resistant. The anaerobic staphylococci were very susceptible to its inhibiting action. Gonococci and meningococci also showed a zone of inhibition of growth in chocolate agar-penicylinder plate tests under increased CO_2 tension. *E. coli, Ps. aeruginosa* and *B. proteus* were not inhibited in agar plate-penicylinder tests or in serial dilution in broth tests.

The *in vivo* protective action of "bacitracin" has been tested against hemolytic streptococcus C203 M. V. in mice. When mice were injected intraperitoneally with 10,000 M. L. D. of an overnight culture of this streptococcus in blood broth, followed immediately by an intraperitoneal injection of one to two units of "bacitracin" in a cell-free filtrate of the antibiotic as harvested, approximately 80 per cent. of the mice survived. When the mice were injected with 10,000 M. L. D. intraperitoneally, followed immediately by a subcutaneous injection of one to two units of "bacitracin," 30 to 40 per cent. of the mice survived. If mice so injected received additional doses of one to two units subcutaneously every three hours for 36 hours, 80 to 90 per cent. survived.

Guinea pigs have been protected against the development of gas gangrene when 1 cc and 0.5 cc of an overnight culture of *C. welchii* or *C. septicum* combined immediately before injection with 50 to 100 units of "bacitracin" in 1 cc of distilled water, was injected into the thigh muscle. These pigs received additional doses of 50 to 100 units of "bacitracin" subcutaneously every three hours for 36 hours. Some swelling and oedema developed at the site of injection of the gas gangrene organisms, but in 80 per cent. of the pigs, this gradually receded and the pigs were alive and well two weeks after the injection. The control pigs injected with a like inoculum of organisms all died within 12 hours. There was no sign of local toxicity from the subcutaneous injection of the "bacitracin," nor was there any toxic general reaction in the experimental pigs or the antibiotic controls.

"Bacitracin" has been used locally to treat a relatively small number of human infections due to hemolytic streptococcus and staphylococcus. The results have been comparable to the response of similar cases to local penicillin. Not enough material has been available as yet for systemic treatment. Attempts are now being made to produce this antibiotic by large-scale commercial methods.

Summary

A new antibiotic "bacitracin" has been recovered from a strain of the *B. subtilis* group of organisms. It is neutral, water-soluble, non-toxic and relatively heat stable. *In vitro* it is active chiefly against Gram-positive organisms, but the gonococcus and meningococcus are susceptible to its action. It is also active *in vivo* against experimentally produced hemolytic streptococcal infections in mice and gas gangrene infections in guinea pigs. Clinical use in hemolytic streptococcal and staphylococcal infections in man have given encouraging results.

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SEROLOGIC EVIDENCE OF CYTOPLASMIC INTERCHANGE DURING CONJUGATION IN PARAMECIUM BURSARIA[1]

THE preliminary experiments reported by the authors[2] on antigenic changes in cultures of *Paramecium bursaria* have been expanded to include serologic examinations of conjugants at various intervals after the onset of the mating phenomenon and at various times following the conclusion of the event. The new work has been done very largely with two strains of the ciliate: one of these is colored brilliantly green by zoochorellae inclusions; the other is colorless. (The color difference is so striking that no difficulty whatever was experienced at any time in determining to which strain either representative belonged.) These two strains are antigenically distinct: each reacts quickly and extensively in homologous antiserum; neither reacts at all in antiserum for the other unless it has undergone conjugation with the other.

The development of a gelatinous precipitate in and about the ciliary zone and the occurrence of ciliary tangling (with eventual loss of action) was taken as positive evidence of antigen-antibody reaction when it appeared within two hours after the paramecia were placed in antiserum. The examinations were made in hanging drop preparations with the "high dry" (4 mm, 44X) objective and 10X ocular of the microscope.

The examination of a large number of paramecia has revealed that about 95 per cent. of all recent (within one hour) ex-conjugants contain some antigenic substance common to their mates which was not previously present within themselves. Moreover, a study of other ex-conjugants has revealed that the

[1] This work was aided by a grant from The Rockefeller Foundation.

[2] J. A. Harrison and E. H. Fowler, *Jour. Immunol.*, 50: 115, 1945.

new antigenic character conferred upon the individual at the time of conjugation persists in its progeny for at least one month of active growth. About 5 per cent. of all recent ex-conjugants seemed to be insensitive to sera which were effective on the cells with which they had mated.

Serologic tests done on pairs of animals while in conjugation have given variable results: in not a single instance have both members of pairs reacted in either antiserum after short periods of conjugation; in many instances both members of pairs have reacted in the antiserum in which they were tested after long periods (12 hours at 28° C. to 40 hours at 19° C.) of conjugation.

All conditions and observations of these experiments make it clear to the authors that the antigen involved in the reaction is very largely, if not exclusively, cytoplasmic in character. We therefore are of the opinion that during the course of conjugation in *Paramecium bursaria* there occurs an extensive interchange of cytoplasm, although it is admitted that the proper explanation of the reactions observed may relate to an alternative suggestion that the cytoplasm of paramecia undergoes a sudden and profound antigenic reorganization with reference to, and influenced by, the cytoplasm of the contiguous animal or the wandering pronucleus received from it. (The opinion that cytoplasmic interchange occurs was strengthened somewhat in finding, on more than one occasion in these experiments, zoochorellae in the conjugant which was previously free of these inclusions. However, this observation can not be taken as conclusive evidence, for it is a fact that under the influence of effective antiserum the conjugating animal is not normal externally, although it may be almost so in its internal organization.)

The position taken here with regard to cytoplasmic interchange during conjugation in paramecia apparently does not conform to the hypothesis held generally by zoologists since the work of Maupas[3] in 1889. An inextensive search through the literature in this field—an admittedly unfamiliar one to the authors—indicates that the only evidence against the occurrence of cytoplasmic interchange in conjugating paramecia is the fact that it has not been observed microscopically. At the turn of the present century Hickson[4] pointed out that this fact should be attributed to an inadequacy of the methods used and should not have been developed into the conclusion that interchange does not occur.

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[3] E. Maupas, *Arch. de Zool. Exp. et Gen.*, (2), 7: 149–517, 1889.

[4] Sidney J. Hickson, *Quart. Jour. Micros. Sci.*, 45: 346, 1902.

THE COAGULATION OF LATEX

THE mechanism of the coagulation of latex is a very brief chapter in most treatises on rubber. The theories are numerous and conflicting. The most widely accepted interpretation is one in which the destruction of the stabilization membrane is postulated. Recently, in Haiti, I made an electrophoretic study of latex involving the determination of mobility rates and isoelectric points. The timing of the migration of individual latex particles obviously necessitated the use of a microscope. This permitted constant observation of the globules, so that not only were their rate and direction of movement observed, but their aggregation as well.

When latex is put into a buffer mixture of a pH value at or near the isoelectric point of the latex, agglutination of the particles takes place. While observing this incipient coagulation of the latex, I was led to the conclusion that though pH values of isoelectric points indicate a protein covering on latex particles, electrophoretic behavior points to a surface which is, in part, non-protein. The very feeble charge on Cryptostegia latex globules in comparison with the greater charge on Castilloa and the still greater charge on Hevea suggests that there is least protein on the Cryptostegia particles, and most on the Hevea particles. This deduction receives even better support from the complete dissimilarity in the mobility curves of Cryptostegia latex particles and the isolated serum proteins. That there is a non-protein component of the particle surface is hardly to be doubted. I thought it very probable that this non-ionizable component is hydrocarbon, the same which constitutes the core of the latex globule.

Direct observation of incipient coagulation also revealed that there is no loss of identity of the globules and no destruction of the stabilization membrane on initial agglutination.

The foregoing experimental findings and the deductions based thereon met with some opposition. The surface of latex particles is generally assumed to be of pure protein, the hydrocarbon presumably not entering into the composition of the stabilization membrane at all.

The expression "stabilization membrane," as commonly used in the chemistry of emulsions, denotes all forms of coating on the surface of the globules, from monomolecular to multimolecular layers. Monolayers may occur in living systems, but multilayers cover cells and natural emulsions. The stabilization membranes of some artificial emulsions may actually be isolated as delicate pellicles. Monolayers receive emphasis because they are more amenable to physical-chemical laws.

When latex particles collide, one of two events could take place, the particle may coalesce, as when

two unprotected oil globules come into contact, or they may adhere and retain their identity. The former event will occur in a stabilized emulsion if, as a result of contact, the protective membranes break down. Through destruction of the membrane the hydrocarbon in a latex globule will be liberated and can then take part in coagulation, together with the protein constituents of the globule surface. If, however, the globules do not lose their identity and the original surface remains intact, then, when the globules collide and adhere, their stabilization membranes are alone responsible for the elastic qualities of the aggregate.

The evidence generally cited as proof that the stabilization membrane of Hevea latex is of protein and is destroyed on coagulation, is the fact that latex film is irreversibly coagulated by dehydration, presumably because the protein is no longer an effective stabilizing agent. This is not very convincing proof. Isoelectric points established by electrophoretic studies[1] give better support to a protein covering on latex particles, for the isoelectric points are protein precipitation maxima. But these studies also give evidence of a non-protein, non-ionizable component in the surface layer of latex globules. I was reasonably content with this evidence, but as the research done in Haiti dealt primarily with electrophoretic behavior and the composition of the surface but not with coagulation *per se*, and not with the fate of the membrane, it seemed advisable to verify my interpretation of coagulation. Although there is no visible destruction of the stabilization membrane on coagulation and therefore no evidence that hydrocarbon takes part in coagulation, release of the hydrocarbon nevertheless is attributed to a breakdown of the surface. Doubting this, I again journeyed into the field, to the Government Agricultural Station at Coconut Grove, Florida, where the director, Mr. Harold Loomis, placed the facilities of the station at my disposal, for which I here express my appreciation. Latices of the following plants were examined: *Cryptostegia grandiflora, C. magagascariensis,* the natural F_1 hybrid of the two foregoing species, *Ficus elastica, Hevea braziliensis, Manihot glaziovii, Funtumia elastica* and *Landolphia droogmansiana.*

The latices of the foregoing eight species of plants showed but slight differences in behavior, principally in isoelectric points. The general conclusions on coagulation are, therefore, applicable to all the species. Differences in behavior were often greater between the twig and trunk latex of the same plant than between different species. I shall, however, restrict my statements to two plants, Hevea and Cryptostegia.

The latices were placed in sodium acetate acetic acid buffers, the pH ranging from 2 to 7. Isoelectric points of the different species varied between pH 3.5 and 4.6.

The first step in the coagulation of latex is the coming together of two globules. On further agglutination there is evidence of polarity for the globules tend to join up in chains (Fig. 1a). Chain formation is greatly increased by stretching. The fibrous appearance of crude rubber in the coagulating vat is a microscopic picture of aggregates of the minute chains to be seen through the microscope.

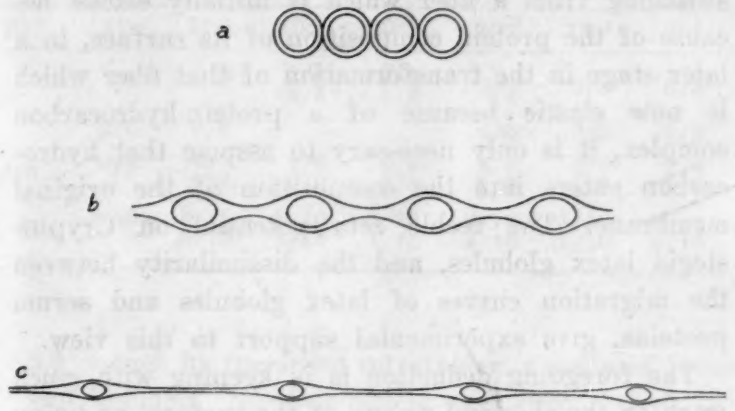

FIG. 1

Several microscopic fibrils or chains of agglutinated globules when grouped in parallel alignment form a microscopic aggregate which can be stretched by hand with the aid of needles. A single microscopic chain may also be stretched by a simple device. When a preparation containing latex at the isoelectric point is so mounted that numerous air bubbles are included, a single chain of latex globules may be found with one end attached to the surface of the glass slide and the other end held by tension to the surface of an air bubble. If now, the air bubble, by slight pressure is made to move to the edge of the slide, the chain of globules, which is actually a delicate strand of rubber, will be stretched. This picture, when viewed under a magnification of 1350x, reveals very clearly that it is the surface layer, the stabilization membrane, which is being stretched (Fig. 1b). Moderate stretching leaves the globules still intact, with no destruction of the membrane. Repeated stretching, done on larger threads which are fascicles of single chains, reduces the size of the globules through incorporation of more and more hydrocarbon from the core of the globule into the surface complex (Fig. 1c). Elasticity, that is to say, the degree of extensibility and rapidity of return, is very great. The globules, which are at first in direct contact, become more and more separated through repeated stretching (Fig. 1, a, b, and c). The intervening substance composing the much stretched thread is crude rubber; it is the former surface layer of the globules which has increased in bulk at the expense of the inner hydrocarbon.

The original membrane, which on initial contact

[1] *India Rubber World,* Aug. and Sept., 1945.

suffered no modification, has now, through repeated stretching, been so greatly modified that it has lost its identity as a surface covering (Fig. 1c). In order to escape the rather incongruous situation of switching from a fiber which is initially elastic because of the protein composition of its surface, to a later stage in the transformation of that fiber which is now elastic because of a protein-hydrocarbon complex, it is only necessary to assume that hydrocarbon enters into the composition of the original membrane. The feeble zeta potential on Cryptostegia latex globules, and the dissimilarity between the migration curves of latex globules and serum proteins, give experimental support to this view.

The foregoing deduction is in keeping with much work on the chemical nature of the surfaces of living cells and natural emulsions. Biologists have long regarded cells as coated with fatty substances. Recently, the milk globule, heretofore thought to be stabilized by casein, has been shown by Palmer[2] and by Moyer[3] to be a complex of phospholipids and protein. Moyer's work on milk is very similar, both as to method and the conclusion reached, to the study on latex reported here.

It is difficult to escape the conclusion that molecular continuity exists between the core and the surface of latex globules, and that the elasticity of crude rubber when first formed resides in a surface layer which is a composite of protein and hydrocarbon.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

SEDIMENTATION OF POLIOMYELITIS VIRUS BY CENTRIFUGATION[1]

NUMEROUS reports have appeared in the literature showing that the virus of poliomyelitis can be sedimented by ultracentrifugation. The original report of Schultz and Raffel,[2] who effected partial purification from infected monkey spinal cord, has been amply confirmed, both for human virus and for the spontaneous mouse poliomyelitis of Theiler.[3,4,5,6] The method has been adapted for the recovery of virus from stools by Melnick,[7] and more recently the same author has demonstrated the presence of virus in the blood of experimentally infected monkeys by this technic.[8]

In all these reports, air-driven ultracentrifuges have been used, running at speeds of 22,000 to 39,000 r.p.m. for periods of one to six hours. It occurred to us that prolonged centrifugation at lower speeds, in an apparatus more readily obtainable and less expensive, might be effective in sedimenting virus.

For this purpose, experiments have been performed using the International Equipment Company Multispeed Attachment on an ordinary Size 2 centrifuge. The head of this attachment, six inches in diameter, holds six tubes at a 45° angle, with a total capacity of 33 cc. Speeds up to 18,000 r.p.m. are obtainable, at which a force 25,000 times gravity is exerted.

EXPERIMENTAL

For all experiments the mouse-adapted Lansing strain of poliomyelitis virus was used. A 20 per cent. stock suspension was prepared in saline and centrifuged at 18,000 r.p.m. for 20 minutes, the clear supernate being stored in ampoules on dry ice. On thawing, some particulate matter appeared which was removed by re-centrifugation at 18,000 r.p.m. for 10 minutes before the experimental tests. For the latter, a period of four hours at 18,000 r.p.m. was arbitrarily selected. Shorter periods were not employed. To keep the centrifuge head below room temperature, the centrifuge chamber was cooled by the addition of about five pounds of dry ice. Centrifugation was interrupted hourly to replenish the supply. Experiments were performed with 20 per cent. and with 1 per cent. suspensions, both in saline.

With 20 per cent. virus a small, transparent, amber-colored pellet was formed. With 1 per cent. virus, a film was deposited over the lower surface of the tube. After centrifugation, the tubes were washed twice with saline, without disturbing the sediment. The gummy sediment was then triturated with a glass rod in a drop of saline, and diluted with saline to the original volume. Resolution was not complete, and in the case of 20 per cent. virus the reconstituted sediment was centrifuged at low speed for a few minutes before diluting it for titration, a certain amount of virus presumably being lost. Mice were inoculated intracerebrally with 0.03 cc of the clear supernate.

The results of four experiments are summarized in Table 1. In the first, the top and bottom thirds of

[1] Aided by a grant from The National Foundation for Infantile Paralysis, Inc.

[2] E. W. Schultz and S. Raffel, *Proc. Soc. Exp. Biol. and Med.*, 37: 297, 1937.

[3] P. F. Clark, A. F. Rasmussen, Jr., and W. C. White, *Jour. Bact.*, 42: 63, 1941.

[4] H. S. Loring and C. E. Schwerdt, *Jour. Exp. Med.*, 75: 395, 1942.

[5] S. Gard and K. O. Pederson, SCIENCE, 94: 493, 1941.

[6] J. L. Melnick, *Proc. Soc. Exp. Biol. and Med.*, 49: 553, 1942.

[7] J. L. Melnick, *Jour. Exp. Med.*, 77: 195, 1943.

[8] J. L. Melnick, *Proc. Soc. Exp. Biol. and Med.*, 58: 14, 1945.

[2] *Jour. Biol. Chem.*, 104: 359, 1934.

[3] *Jour. Biol. Chem.*, 133: 29, 1940.

TABLE 1

RESULTS OF CENTRIFUGATION OF 20 PER CENT. AND 1 PER CENT. VIRUS SUSPENSIONS IN SALINE

Experiment number	Concentration centrifuged Per cent.	Concentrations of original tissue										
		Control virus				Supernate				Sediment		
		10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-2}	10^{-3}	10^{-4}
I	1—Top third						8/8	2/8	2/8	6/8	5/8	0/8
	1—Bottom third							4/8	1/8			
II	20	5/6	4/6	2/5		2/6	0/6			6/6	3/5	3/6
III	20					0/6	0/6	1/6	0/6	6/6	0/6	2/6
	1		5/6	3/6	2/6		2/6	2/6	0/6	2/6	1/6	0/6
IV	20					1/10	0/10	1/10	0/10	9/10	5/10	0/10
	1		7/9	5/10	1/10		5/10	5/10	1/10	4/10	1/10	0/10

Numerator: number of mice with proven poliomyelitis.
Denominator: number of mice injected.

the supernate were tested separately, to determine whether concentration rather than sedimentation might have taken place. Supernate after the preliminary centrifugation was used as control virus in each experiment. In the table, all dilutions refer to concentration of original tissue.

With only a few exceptions, all mice found dead without previously observed symptoms, during a period of five weeks after inoculation, were studied histologically. Sections of brain and cord were examined at 0.8 mm intervals. Only those with paralysis or with typical lesions were considered as having had poliomyelitis.

It will be seen from Table 1 that when 20 per cent. virus was centrifuged, very little activity remained in the supernate, and there was almost quantitative recovery in the sediment. With 1 per cent. virus, considerable amounts remained in the supernate, although virus could be recovered in the sediment.

The effect of homologous normal serum, one-tenth volume, in promoting sedimentation was next tested. The comparative effects of saline and of serum, respectively, on sedimentation, using 1 per cent. virus, are shown in Table 2. The presence of serum results in the formation of a discrete pellet, similar to that formed from more concentrated virus suspensions. The results of this experiment indicate that virus can be recovered quantitatively in the sediment from dilute suspension by the addition of serum.

The purpose of the study was to develop a simplified technic for recovery of virus from biological material. Four stools from human paralytic poliomyelitis patients, in the first week of the disease, have been tested. Heavy suspensions of stool were prepared in water. After preliminary centrifugation at low speed and at 18,000 r.p.m. for 30 minutes, the supernate was centrifuged at 18,000 r.p.m. for four hours. A small translucent or opaque pellet formed. It was treated as described and diluted to a total volume of 1.8 cc in saline. The resulting suspension was treated with ether for from 4 to 18 hours. Two rhesus monkeys for each stool were inoculated with 0.8 cc each by the direct intrathalamic route of Howe and Bodian.[9] No toxic effects were encountered. As controls, two rhesus monkeys for each stool were given daily intranasal instillations of untreated suspension for 4 to 10 days.

Two specimens were positive by both methods, two negative by both. Thus, the results are inconclusive so far as the use of this technic is concerned for the detection of virus in biological material where it might otherwise be missed. It does, however, offer a simplified means for the preparation of material for intracerebral inoculation, for which bacteria and toxic substances must be removed. No experiments have been performed in which stool suspensions were centrifuged in the presence of normal serum.

TABLE 2

COMPARATIVE RESULTS OF CENTRIFUGATION OF 1 PER CENT. VIRUS SUSPENSIONS IN SALINE AND IN 10 PER CENT. NORMAL SERUM

		Dilutions of original tissue		
		10^{-2}	10^{-3}	10^{-4}
Control virus (in saline)		5/10	3/10	1/10
Centrifuged in saline	Supernate	7/10	5/10	1/10
	Sediment	9/10	2/10	0/10
Centrifuged in serum	Supernate	0/10	0/10	0/10
	Sediment	10/10	6/10	3/10

Numerator: number of mice with proven poliomyelitis.
Denominator: number of mice injected.

SUMMARY

A technic is described whereby poliomyelitis virus may be sedimented by centrifugation for four hours at 18,000 r.p.m.

Virus has been recovered quantitatively in the sediment from a 20 per cent., but not a 1 per cent., saline suspension. The addition of 10 per cent. normal serum results in quantitative recovery from a 1 per cent. suspension.

Virus has been recovered by intracerebral inocula-

[9] H. A. Howe, H. A. Wenner, D. Bodian and K. Maxey, *Proc. Soc. Exp. Biol. and Med.*, 56: 171, 1944.

tion from two of four human stools tested by the method described.

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NEW PROTECTION FOR FIELD DATA

MAPPING of vegetational types on the U. S. Fish and Wildlife Service's Patuxent Research Refuge, Bowie, Maryland, led to a search for a protective covering for field maps. The problem was solved by a commercially available acetate sheeting treated with a pressure sensitive adhesive. Developed as an easily applied protection for maps for the Army and Navy and commended after ample trial overseas, this material promises to be a boon to scientists who have long suffered with muddy maps and dog-eared data sheets. Easily peeled from the backing attached in manufacture, the film is simply smoothed with thumbnail pressure onto aerial photos, topographic or vegetational maps, relative humidity tables and other data subjected to repeated use, furnishing a transparent and waterproof covering.

While two types are available, clear and matte, the matte variety is quite transparent enough for most purposes and has the great advantage that it can be marked with pencil, crayon or ink (in washes as well as lines). Such marks adhere well but can be easily erased without damaging the surface. In this way, numerous changes can be made without defacing the original beneath. At the Patuxent Research Refuge, the matte finish was found excellent for covering aerial photos, eliminating the glare from glossy prints without appreciably obscuring the details. When these photos were used for mapping vegetation, probable cover-types were speedily delineated in the laboratory, using an ordinary pencil. Then a relatively small amount of field work, using a red lead, sufficed to confirm or amend the boundaries and to delimit sub-types indistinguishable on the photographs.

When one area is under continuous scientific study, as at the Patuxent Research Refuge, wildlife census data or other observations can be recorded in the field on a map thus protected. After being copied and/or tabulated, the data can be erased leaving the map ready for use again.

Brief preliminary tests indicate many other uses for this material. For instance, the clear variety cut in strips can be used as a herbarium mounting tape in conjunction with the usual type of tape. Not requiring moistening and being transparent, it seems admirable for securing the more delicate plant parts. Its initial adhesion is not adequate to hold the more refractory parts, but where it does stick, it is claimed to form a permanent bond with the paper. Also, in the classroom, the sheeting can be used as a protective covering for illustrative material handed around for student use.

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DISCUSSION

THE BUSH REPORT AND SENATE BILLS

IN compliance with a request from President Roosevelt, dated November 17, 1944, Dr. Vannevar Bush undertook to advise the Government how science might be organized to serve our country in future days of peace as effectively as it was serving our armed forces during the war. In particular, the President inquired (a) what could be done, consistent with military security, to make known to the world the contributions to scientific knowledge during the war; (b) how a program might be organized to continue the scientific advances that had been made in the fields of medicine; (c) what the Government might at once and in the future do to aid research by public and private organizations; and (d) whether an effective program might be set up for discovering and developing scientific talent in American youth.

Dr. Bush appointed large committees of distinguished men to study and report on the four principal subjects enumerated above. After months of labor these committees presented comprehensive reports, on the basis of which Dr. Bush made his report in compliance with the President's request. The report is developed under six chapter headings as follows: I, Introduction, a statement of the reasons that progress in science is essential and the relations of the Government to it; II, The War Against Disease; III, Science and the Public Welfare; IV, Renewal of Scientific Talent; V, A Problem of Scientific Reconversion; and VI, The Means to the End.

Under Chapter VI the report proposes a "National Research Foundation," including its purposes, its membership, its organization, its functions and duties, its patent policy, provisions for special authority, and its budget for five years. In short, it is a report that states a general problem of great importance, dissects it into its major components, sets up principles and outlines machinery for its administration, and proposes a financial budget, all fortified by comprehensive analyses and supporting data by very competent committees.

In spite of the excellence of the Bush Report, spe-

cialists in the fields of the biological sciences and of the social and economic sciences, not to mention the humanities, on reading the recommendations would be conscious of serious gaps in it. They would find no references to biological sciences, except as they may be involved in medicine, and no direct recognition of the possible importance of social and economic sciences. The nearest to such recognition is the oblique statement, "It is our hope and belief that the provision of funds for the natural sciences would, in some measure, free university funds for use in the other fields." This statement echoes faintly, too, the pressure from many universities and colleges for support from the Federal Government, and indeed violates some of the principles enunciated earlier in the report.

The Bush Report is probably at least partly responsible for four bills relating to governmental support of science which have been introduced in the United States Senate and referred to the Subcommittee on War Mobilization of the Committee on Military Affairs, of which Senator Elbert D. Thomas, of Utah, is chairman; and for one bill introduced in and passed by the House of Representatives but not acted on by the Senate. These bills are: S. 825, sponsored by Senator Byrd; S. 1248, sponsored by Senator Fulbright; S. 1285, sponsored by Senator Magnuson; and S. 1297, sponsored by Senators Kilgore, Johnson and Pepper. The House bill was sponsored by Congressman May. By arrangement among the sponsors these bills will be considered at joint hearings with the hope that out of them a new bill may be drawn that will be acceptable to all who are interested.

It is at the hearings that scientists may most effectively present their views. The sponsors of the bills desire the views of scientists so that the final result shall be as advantageous for the country as possible. Unfortunately the pressures upon members of Congress are so great that they can not be expected to attend all or any considerable part of the hearings. It follows that all presentations of data and conclusions should be in writing, even if those making them appear in person.

According to present schedule, hearings of representatives in the fields of the biological sciences will be on October 24; in the fields of the physical sciences, on October 25 and 26; in the fields of the social sciences, on October 29; and in the fields of engineering, on October 30.

If it is impossible for any of the affiliated societies to send representatives to present their written statements, the Association will undertake to get them properly before the Senate Committee and into the records of the hearings.

F. R. MOULTON

PROPOSED UNIT FOR HIGH VACUUM

IN a recent letter[1] Dr. Paul E. Klopsteg has expressed himself in favor of adopting the suggestion made by F. H. Townsend,[2] of a unit for high vacuum which like the unit of sound intensity is based on a logarithmic scale. If we denote the pressure in *mm* of mercury by P, then the "units of vacuum" (u) are given by the relation

$$u = -10 \log P$$

Thus 1×10^{-3} mm = 30 u
2×10^{-5} mm = 47 u.

It should be observed that the reason for adopting a logarithmic scale in the case of sound intensity is based on the validity of Fechner's law. On the other hand, in the case of gases, it is extremely convenient to measure pressures by a direct-reading gauge, such as the McLeod type. Furthermore, at low pressures most properties of gases vary practically linearly with the pressure, so that it is possible to extrapolate to very low pressures by means of gauges calibrated at the higher range of pressure by means of a McLeod gauge.

The writer can see no advantage whatever that would be gained by adoption of the suggested "unit of vacuum." Rather, it would be a source of confusion in both laboratory and factory work, and would certainly be of no help in the application of any equations derived on the basis of the kinetic theory. We have a very logical unit of pressure, the dyne per cm² (1 microbar). Let us stick to c.g.s. units as much as possible.

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MYCOFLORA OF BUDS

NO reports on the occurrence of fungi and bacteria in the tissues of normal foliar buds have come to the writer's attention. Such organisms are known to occur in nectaries and other floral structures. Cultures from entire buds, bud scales and meristems from several species of trees were prepared on various media in this laboratory. In every instance, the materials were surface-sterilized, by accepted techniques, previous to implantation in the nutrients. The buds were selected from apparently healthy trees and from external appearances were perfectly formed and normal. Included in the investigation were species of *Aesculus, Cedrela, Fraxinus, Ginkgo, Magnolia, Populus* and *Robinia*. Several species of fungi and bacteria and a few actinomycetes were isolated. Most

[1] SCIENCE, 102: 208, 1945.
[2] *Nature*, 155: 545, 1945.

of the fungi belong to the Ascomycetes and the Fungi imperfecti. In at least two instances, a distinct specificity of fungi for certain species of trees was exhibited. Results indicate that some species of fungi are quiescent during the period of bud dormancy. In addition, although many of the species could be isolated throughout the year, they were most abundant at the time of the opening of the buds. Some species were obtained at this time which were not observed at any other period.

Since the frequency of fungi and bacteria increased with the opening of the buds, the question is raised of the possible physiological rôle these organisms may have in bud and shoot development. It has been reported in the literature that auxins capable of accelerating the development (". . . die Entwicklung . . . fördern können") of winter buds of lilac (*Syringa vulgaris*) were isolated from culture media in which *Saccharomyces cerevisiae* and *Penicillium luteum* were grown.[1]

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SCIENTIFIC BOOKS

JOHN MERLE COULTER

John Merle Coulter. By ANDREW DENNY RODGERS, III. viii + 321. Princeton, N. J.: Princeton University Press. 1944. $3.75.

THE life of a botanist, like that of an industrialist, may be a "success story," advancing from the humblest beginnings, not indeed to wealth and power, but to dignity and glory. The life of John Merle Coulter, moreover, like that of many another recent American botanist, coincided with the great advance of botany in this country from its own humble beginnings to its present peak of prestige. Coulter, the son of a missionary to China, landed in this country in 1854, aged three years. At that time Torrey was working on collections made in surveying routes for a railroad to the Pacific. Young Gray had but recently published his "Manual," and Chapman had not yet written his "Flora." The Smithsonian Institution was about six years old, the National Academy of Sciences not yet in existence. The alternation of generations was unknown and the origin of the embryo of flowering plants a mystery. The cell theory was a novelty, physiology was little more than a name and evolution not even that. Botany was the determination and naming of plants "according to the natural system." In contrast with this pastoral scene, the last years of Coulter's life were spent at an institute for plant research where taxonomy is eschewed and botany merges into biochemistry—replete with auxins, hormones, vitamins and all the wonders of the age. Botany had become plant physiology, pathology, mycology, anatomy, ecology, genetics and other things. It is the story of these years that Andrew Denny Rodgers unfolds for us in the latest of his works.

It is perhaps not always now remembered that Coulter earned recognition first as a taxonomist, beginning with the collection of the flora of Indiana and working up to the great revision of the Umbelliferae with J. N. Rose. But Coulter had genius not only for rising to eminence in a particular field but for adapting himself to the changing spirit of the times and assimilating what was new into the old frame of ideas. He early became interested in morphology, and successfully used new morphological criteria in his taxonomic work. He founded the *Botanical Gazette*, chiefly for taxonomic articles, and lived to see it become one of the chief vehicles in the world for the publication of botany in all its branches. Taxonomy remained until the end one of his chief interests; but he was quick to embrace the evolutionary doctrine, and to turn his morphological learning into phylogenetic research and speculation. Perhaps more than any other botanist he is identified with the great advance of the last century in botanical thought.

The author submits "that employment of a biographical method does not necessarily interfere with either accuracy or fullness of historical narrative." To which contention the present reviewer would reply that this is not really a biography at all; it is a panorama with a central figure. Every contemporary figure in American botany is treated in some detail, and the narrative frequently wanders far from its announced theme for dozens of pages at a time. For instance, one third of the chapter entitled "The Years at Wabash College" is devoted entirely to other botanists. Chapter 10, entitled "Pure and Practical Science," contains 15 consecutive pages in which Coulter is scarcely mentioned. This is not said in disparagement of the work. On the contrary, such an array of highly accurate historical information is impressive and can not fail to be useful. But it is scarcely biography.

Coulter was not only a progressive scientist; he was an inspiring teacher and an able administrator; as he developed the Department of Botany at the University of Chicago, he demonstrated his ability to attract others who became leaders in their fields. To these qualities his fame owes as much as to his intellectual

[1] Anneliese Niethammer, *Gartenbauwissenschaft*, 14: 651, 1940.

achievements. There is little, however, in this work to portray to us the human lineaments, the personality of its subject. One aspect of Coulter's mental life is indeed suggested from time to time; his devotion to an orthodox religion which survived unshaken his acceptance of evolution and of deterministic science in general. Most scientists, more or less unconsciously, shed their religion or keep it in a sealed compartment somewhere where it can not interfere with their thinking. It would be interesting to know, even to try to find out, how Coulter managed his own reconcilement. In this we get no help from Rodgers. Indeed, he falls into the attitude characteristic of so much of what passes now for biography—an uncritical reverence for his subject; the hero can do no wrong. This tends to slop over into his environment, so that from the little college where he first studied to the great institute where he passed his last years, we are invited to admire everything with which Coulter had dealings.

The book is attractively produced, and the publishers are to be congratulated on what seems to be good material for these years. It is a matter of surprise, however, that a work which bears the imprint of a university press should apparently never have been edited. At least it is full of the most obvious and elementary mistakes in grammar and punctuation. These, with the curiously naive style, the mixed metaphors and the hackneyed phrases, the sudden outbursts of hyperbole, can not but detract from its value as literature and from any pleasure in its perusal. It is as a reference work for North American botanists of the second half of the nineteenth century that it should have its greatest use; in that way it should be very useful indeed.

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SOIL FUNGI

A Manual of Soil Fungi. By JOSEPH C. GILMAN. xi+392 pp. 135 figs. The Iowa State College Press. Ames, Iowa. 1945. $5.00.

THE author's interest in soil fungi dates back to the early 1920's when he and Abbott started a systematic study of the fungi isolated from soils of Iowa and Louisiana. Their 118-page paper, "A Summary of the Soil Fungi," published in 1927, described 242 species of fungi in 61 genera. Twenty species were described as new to science, and six old species were described from the soil for the first time. Over half of the total number of species described were isolated and studied by the authors; the descriptions of the remaining 115 were compiled from the reports of other writers from all over the world. This seems to have been the first systematic attempt to get together descriptions of the more common soil fungi.

The present volume is a revision and extension of this early paper, which has long been out of print. Descriptions of 795 species of soil fungi are given, over three times the number of species included in the 1927 paper. As the author states in the preface, the book contains little new data, but is a compilation, for the most part, of the works of others. It is intended as a tool to assist investigators in identifying soil fungi. The need for such a book is clearly indicated by the fact that though numerous monographs on soil-inhabitating groups have been published, no one since 1927 has brought together all the known soil fungi in one volume.

Included in the manual are those fungi which have been isolated from the soil and cultivated artificially. Excluded are the terrestrial mushrooms, soil-borne plant pathogens which have not been directly isolated from the soil and forms which have been reported on leaf-mold, decayed wood and other substrates not fully incorporated in the soil. The Actinomycetes, Myxomycetes and Zoopagaceae are also omitted. All four groups of the true fungi are represented in the manual, the Basidiomycetes by only one, *Pellicularia filamentosa,* and the other three by many species. The genus Penicillium is the most abundant with 189 species from the soil, with Fusarium, Mucor, Aspergillus and Achlya coming next in the number of species in the order named. Many of the species described here are already recognized as very important organisms in medicine, industry and in the spoilage of food and various cellulose, leather and other products. Most of the fungi involved in the deterioration of military material in the tropics are the common soil fungi described here.

The book is well furnished with keys for identification of the classes, orders, families, genera and species. The descriptions are well written and the figures (a total of 135) will be helpful in identifying the genera and species. Following the descriptive text is a list of "Pertinent Literature" with 169 titles and a glossary of several hundred terms.

The book seems to be remarkably free from errors. On page 64, Figure 19 is wrongly labelled *Blastocladiella* when both "a" and "b" should be *Blastocladia parva.* Figure "a" seems to be a combination of Whiffen's figures 21 and 22, and "b" is a misleading reproduction of Whiffen's figure 32. Figure 21, labelled *Blastocladia,* is unlike any figure of Whiffen's, but is very much like some of Indoh's figures. On page 56, Thaxter is credited with *Cunninghamella,* when the authority should be Matruchot.

The book makes no pretense of telling what functions the soil fungi perform or even in what kind of soil the various species are found. A review such as this can only call attention to what the author has

tried to do; how well he has succeeded will be determined by using the book. The reviewer expects to find the book very useful indeed and believes others will also.

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THE BLOOD IN CHILDREN

Atlas of the Blood in Children. By KENNETH D. BLACKFAN, and LOUIS K. DIAMOND. With illustrations by C. MERRILL LEISTER.

THIS well-written and beautifully illustrated book is a much needed contribution to hematology. While this atlas specifically concerns the blood disorders in children, the excellent series of plates and accompanying subject material are applicable to all age periods. The preliminary text of this book comprises six chapters which serve as an explanatory and directing manual for the illustrations that follow. The first chapter deals with the morphology of normal blood cells, their derivation and hematopoietic changes, incident to growth and development. In the subsequent chapters there is a concise discussion of the common blood dyscrasias, according to the predominating blood element involved. Dr. Blackfan and Dr. Diamond demonstrate their unusual experience in pediatric hematology by their expert choice of the essentials in the description of each disease. These authors have successfully accomplished their stated purpose of merging a consideration of the morphologic changes in the blood with the associated clinical manifestations of each disease. The presentations are complete and their value has been enhanced by the inclusion of illustrative case reports.

The second section contains seventy unusual plates of superb artistry, portraying faithfully the typical cells found in the diseases described in the preceding text. A primary consideration in appraising the merits of any hematology atlas rests on the accuracy with which the author reproduces the finer morphologic details of the blood cells. Dr. Leister has achieved this goal with such perfection that the plates prepared by him will serve as an invaluable guide for all those who depend upon standard textbooks for precise identification of the cellular elements of the blood. Line drawings facing each plate permit comparison with corresponding cells and increase the usefulness of this atlas. The series of plates should prove of great practical value in a field of medicine where the correct diagnosis frequently depends upon the accurate classification of a particular type of blood cell.

It is pointed out in the preface that the text of the atlas has been kept necessarily brief. It has not been possible, therefore, to include detailed discussions of normal and pathological alterations in the blood, an outline of technical procedures, a complete bibliography and reference to some of the more recent contributions of hematology in childhood. The atlas should serve as a required companion volume for the more comprehensive works on hematology.

The authors should be complimented on the excellence of this book. Acknowledgement should also be made for the material support provided by the Commonwealth Fund in making this publication possible. This book is highly recommended for use by the medical students, pediatricians, internists and hematologists.

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